

Appl. No : 10/655,690  
Amdt. dated : 04/04/04  
Reply to Office Action of 03/26/04

**REMARKS/ARGUMENTS**

Examiner Calvin Lee is thanked for thoroughly reviewing the subject application.

Favorable reconsideration of this application in light of the above amendments and the following remarks is respectfully requested. All claims are believed to be in condition for allowance.

Claim Rejections - 35 U.S.C. § 103(a)

Reconsideration of the rejection of claims 1-45 under 35 U.S.C. 103(a) as being unpatentable over Shields et al. (U.S. Patent 6,214,742 B1) in view of Merchant et al. (U.S. Patent 6,410,986 B1) is respectfully requested based on the following.

Shields et al. provides a process for post-via tin removal, which is used in order to improve via resistance performance.

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More specifically, Shields et al. provides for:

- Fig. 3A: a layer 302 of dielectric, (optionally) a conductive via 306 through the layer 302, a metal contact 304 overlying the (optional) via 306, a layer 310 of TiN formed over the metal contact 304, a layer 308 of ILD, a layer 312 of P.R.
- Fig. 3B: the layer 312 of P.R. is patterned, creating an opening 314 there-through that is aligned with the metal contact 304
- Fig. 3C: etching the layer 308 of ILD in accordance with the patterned layer 312 of P.R. (the P.R. etch mask)
- Fig. 3D: etch layer 310 of TiN in accordance with the patterned layer 312 of P.R., remove the patterned layer 312 of P.R., and
- Fig. 3E: deposit a barrier layer 316 over inside surfaces of the opening 314 and fill the opening 314 with a conductive material 318.

Shields et al. has, in providing the above briefly highlighted processing sequence, provided, as can be verified from fig. 3E of Shields et al. and as highlighted in col. 6, lines 44 e. a. of Shields et al., for removing the layer 310, which is a high-resistivity layer of material, from the "stack"

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of layer of the (optional) a via 306, the metal contact 304, the barrier layer 316 and the conductive material 318.

This removal of the layer 310 of TiN has the dual purpose of improving resistive performance of the created conductive interconnect and of eliminating, see text col. 6, lines 43 e.a., the needs to remove residual particles from the created hole 314.

Merchant et al. provides for a multi-layered barrier structure that comprises TiN. More specifically, Merchant et al. provides for:

- Fig. 3, a multi-layered structure 50 of overlying layers of TiN, formed over a layer 54 of dielectric, an aluminum contact 58 formed over the structure 50; structure 50 is created over an initial glue layer 52 of Ti, which is interposed between structure 50 and the underlying layer 54 of dielectric; the structure 50 may contain any (desired) number of layers of TiN
- Fig. 4, as Fig. 5 with in this case a W contact plug formed over the multi-layered TiN structure 60, structure 60 being formed over a glue layer 62

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- Fig. 5, a multi-layered structure formed over an initial glue layer 80, which has been deposited over a dielectric layer 82. Over the glue layer, the multi-layered structure is provided by Merchant et al., containing alternating deposits of a layer (such as layers 86, 90) of TiN which are interspersed with layers (such as layer 88) of Ti; in short: the multi-layered structure provided by Merchant et al. as shown in Fig. 5 of Merchant et al. comprises a stack of layers of TiN - Ti - TiN - Ti - TiN, etc.

The summarize the cited prior art, Shields removes TiN from a the surface of a metal contact, for reasons cited above, Merchant provides for a multi-layered titanium barrier layer containing either TiN or alternately containing layers of TiN and Ti.

Of the rejected claims 1-45, claims 1, 11, 20 are independent method claims while claims 28, 36 and 39 are independent structure claims.

One of these independent claims will be quoted following, in order to highlight the essential aspects of the claimed

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invention that are not provided by Shields et al. and Merchant et al., singly or in combination, using independent claim 1 for this purpose in abbreviated form, which specifies the process of the claimed invention for the creation of a metal interconnect over a layer of adhesion material and a layer of barrier material having a thickness, as follows:

- providing a substrate
- depositing a layer of dielectric over the substrate
- patterning and etching the layer of dielectric
- depositing a layer of adhesion material over the layer of dielectric
- depositing a layer of barrier material over the layer of adhesion material, the layer of barrier material comprising a first or lower and a second or upper layer of barrier material separated by a central layer of adhesion material
- depositing a layer of conductive material over the layer of barrier material
- removing excess material from the layer of dielectric.

The above underlined and highlighted aspects of the claimed invention are not provided for nor alluded to by Shields et al. and Merchant et al., singly or in combination.

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The claimed invention provides an improved method for the creation of a barrier layer for a tungsten interconnect, the improvements are affected by reducing metal extrusion and effects of pin-holes, by dividing the process of barrier material of TiN deposition **into two phases**, whereby:

- **a first phase** of the creation of a barrier layer: about half the thickness of the required layer of TiN is first deposited, after which
- **an intermediary phase** is interposed in the creation of a barrier layer: an intermediate and very thin layer of Ti is deposited, after which
- **a second phase** of the creation of a barrier layer: the deposition of the barrier layer of TiN is continued to the point where the required thickness for the layer of TiN is reached.

The remaining independent claims of the claimed invention which, in the interest of brevity, will not be quoted at this time essentially, follow a similar processing sequence as highlighted above for independent claim 1.

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Regarding the independent claims with claims 7-8, 11-27, 34-38 and 44-45, the following comments apply.

That the process of the claimed invention is very application dependent, and not, as for instance the Merchant et al. invention where a number of overlying layers are created to serve as a barrier structure, is further shown by the dependent claims of the claimed invention. These dependent claims specify in detail how the steps of the claimed invention relate to each other. For instance, claims 2 through 10 specify necessary and required detail such that the claimed invention can be completely and unambiguously implemented by one skilled in the art, as follows:

- the point of electrical contact comprising aluminum (claim 2)
- the adhesion material comprising Ti (claim 3)
- the barrier material comprising TiN (claim 4)
- the central adhesion material having a thickness between about 10 and 50 Angstroms (claim 5)
- the conductive material comprising tungsten (claim 6)
- the first or lower layer of barrier material having a thickness between about 0.40 and 0.60 of a thickness of a layer of barrier material (claim 7)

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- the second or upper layer of barrier material having a thickness between about 0.40 and 0.60 of a thickness of a layer of barrier material (claim 8)
- the first layer of barrier material having a thickness between about 100 and 175 Angstrom (claim 9), and
- the second layer of barrier material having a thickness between about 90 and 125 Angstrom (claim 10).

These dependent claims have been cited above in order to demonstrate that the claimed invention must be implemented in a very well defined manner in order to provide a method of creating:

- a barrier layer for a tungsten interconnect
- a barrier layer for a tungsten interconnect whereby effects of temperature increase are minimized, and
- a barrier layer for a tungsten interconnect without introducing metal extrusion.

While applicant acknowledges the teachings of Shields et al. and Merchant et al. as cited by the Examiner, and although applicant does not necessarily agree that the Examiner's arguments show sufficient and proper basis for suggestion or



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motivation to modify or combine Shields et al. with Merchant et al., applicant nonetheless also asserts that there is absent within the portions of Shields et al. and Merchant et al. or any combination thereof, as cited by the Examiner, an express or inherent teaching of each and every limitation within applicant's invention as taught and claimed by the claimed invention.

In this regard, applicant claims that there is absent from the portions of Shields et al. and Merchant et al., or any combination thereof, as cited by Examiner, a teaching of creating a barrier layer for a tungsten interconnect whereby effects of temperature increase are minimized and without introducing metal extrusion.

None of the applied or known references address the invention as shown in the claims of the claims of the claimed invention in which a method is provided whereby a relatively thick layer of barrier material can be created **without suffering** a negative impact of increasing temperatures of the substrate during barrier layer deposition.

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The invention is believed to be patentable over the prior art cited, as it is respectfully suggested that the combination of these various references cannot be made without reference to Applicant's own invention.

None of the applied references address the problem of with increased thickness of the deposited layer of TiN, the temperature of the substrate increases during the deposition of the layer of TiN and whereby, if a relatively thick layer of TiN is deposited in one processing step, the temperature of the substrate may increase to the point where metal extrusion takes place.

Applicant has claimed the process in detail. The processes of Figs. 8-14 are believed to be both unique and patentable over these various references, because there is not sufficient basis for concluding that the combination of claimed elements would have been obvious to one skilled in the art. That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of these various references is desirable. We believe that there is no such basis for the combination. We therefore request Examiner Calvin Lee to

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withdraw the rejection of claims 1-45 in view of these arguments.

In light of the foregoing response, applicant respectfully requests that the Examiner's rejection of claims 1-45 under 35 U.S.C. 103(a) as being unpatentable over Shields et al. (U.S. Patent 6,214,742 B1) in view of Merchant et al. (U.S. Patent 6,410,986 B1), be withdrawn.

#### Other Considerations

No new independent or dependent claims have been written as a result of this office action, no new charges are therefore incurred due to this office action.

It is requested that, should Examiner not find the claims to be allowable, to call the undersigned Attorney at the Examiner's convenience at 845-452-5863 in order to overcome any problems preventing allowance of the claims.

Respectfully submitted,



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